Speeding through the “Valley of Death”: More rapid and efficient transition of instruments and platforms from research to operations

Dr. Alexandra R. Isern
National Science Foundation (NSF)
Division of Ocean Sciences
4201 Wilson Blvd
Arlington, VA 22201 USA
aisern@nsf.gov

Dr. Andrew M. Clark
Maritime Communication Services (MCS)
HARRIS Corporation
1025 W. NASA Blvd
Melbourne, FL 32919, USA
Andrew.Clark@Harris.com

***Abstract*- This paper focuses on how enhanced cooperation and interaction between the research, operational, and industrial communities can help break down boundaries to better leverage advancements in platforms and sensors and to more rapidly transition instrumentation from the bench top to real-world applications. Existing success stories in the research to operations transition can be used to help establish processes and mechanisms that will enable more rapid and efficient transition of technology through the “valley of death”. This paper will also discuss ways to help ensure that the oceanographic tools needed by the operational community are in the visionary pipeline of the research community.**

I. Introduction

The advent of the “observing age” and the associated rapid transformation in ocean science and operations from an expeditionary mode to an increased reliance on *in situ* measurement systems has created a great demand for platforms and sensors that are robust, can be operated remotely or autonomously for extended periods of time, and that can provide data related to high priority oceanographic parameters. Meeting this demand in a timely manner has proven to be difficult. In part, this difficulty results from the fact that the harsh ocean environment places constraints on designers and developers that are time-intensive and costly to overcome when developing sensors and platforms. A result of this is that it may take decades to design, develop, and test a sensor or platform to the extent that is required for reliable “operational” use whether on a research or operational platform. Another difficulty is that, in the past, the demand for ocean sensors and platforms has been small compared to that for other industries and therefore research and development funds within ocean instrumentation companies was scarce and much sensor and platform development was reliant on funds from Federal agencies. The demand for sensors and platforms may increase dramatically with the installation of new and enhancement of existing observing systems through the National Science Foundation’s (NSF’s) Ocean Observatories Initiative (OOI) and the multi-agency Integrated Ocean Observing System (IOOS). This increased demand may enable a change in the current business model for ocean instrumentation development.

Despite these difficulties there have been many successful transitions of research sensors and platforms to routine operational use. The ARGOS network of floats was developed and continues to evolve through the incorporation of new technologies from research as well as through the interaction of the research community and operational users. Sensors that can detect organisms responsible for harmful algal blooms moved rapidly from the bench top to deployment in operational systems. The use of gliders as a platform for a broad array of sensors has expanded rapidly and the reliability of this platform has dramatically increased since their first test deployments a few years ago. These successes have resulted from numerous factors discussed in this paper.

To serve research and operational needs there are still many technological advances that need to be made, the results of which then must be efficiently transitioned to operational use. There is a great demand for chemical sensors that can not only measure quantities of naturally occurring elements and compounds there is also a great need for those that can determine the concentration of anthropogenic compounds. Similarly, there are broad and diverse needs for biological sensors that range from measurement of compounds to quantification and identification of species. The development of efficient and effective methods to reduce or overcome biofouling is essential if reliable measurement systems are to be deployed for long periods of time. The supply of sufficient power for platforms and sensors as well as mechanisms to

1-4244-0115-1/06/$20.00 ©2006 IEEE

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 SEP 2006	**N/A**	**-**

4. TITLE AND SUBTITLE
Speeding through the Valley of Death: More rapid and efficient transition of instruments and platforms from research to operations

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Science Foundation (NSF) Division of Ocean Sciences 4201 Wilson Blvd Arlington, VA 22201 USA

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002006. Proceedings of the MTS/IEEE OCEANS 2006 Boston Conference and Exhibition Held in Boston, Massachusetts on September 15-21, 2006. Federal Government Rights, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**5**	

provide bandwidth for data transmission remains significant challenges to ocean observing systems.

II. ACADEMIC SECTOR EXPERIENCE

User needs in the research and operational communities are often significantly different resulting in tools for research that do not meet the needs of the applied user. Also, the harsh ocean environment places constraints on designers and developers that are time-intensive and costly to overcome and often delay the transition of sensors and platforms to more routine operational use [1]. Another difficulty is that, in the past, the demand for ocean sensors and platforms has been comparatively small and therefore research and development funds from industry were scarce and much sensor and platform development was reliant on limited agency funding.

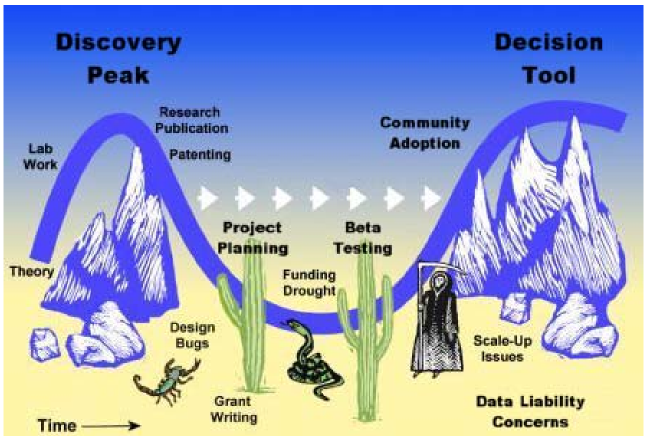

Figure 1. “Valley of Death” Transition in an Academic Environment

The “Valley of Death” transition from seminal discovery to societal impact has long been problematic in academia (Fig. 1). In the example depicted in figure 1, data that have been collected, analyzed, and used as input to models that ultimately serve as the basis for a decision support tool. One example of such a successful transition may be found in the decision support tool known as “HAZUS” Disaster Management Risk Prediction developed by the National Aeronautical and Space Administration (NASA) for the Federal Emergency Management Agency (FEMA) [2]. Utilizing observational data and model fields characterizing precipitation, runoff, storm surge and other parameters, decision makers are provided an output in terms of flood affected areas, evacuation zones and predictions of financial losses. The Valley of Death metaphor tends to invoke imagery of an arid and desolate gulch. However, as depicted in figure 1, in the academic arena, the terrain between initial concept and realization of an end product is actually strewn with myriad distractions, obstacles and is fertile with alternate paths of distraction. Additional research proposals must be submitted (and resubmitted) and manuscripts must be prepared and published. Sponsoring agencies may change the focus of research most favored for funding and promising but high risk ideas may have to be forgone for pursuits representing more of a “sure thing”.

The vast majority of innovations emerging from the research community is funded by a handful of federal and state agencies and thus are largely driven by missions requirements. The measure of time required for important technical innovations to mature and emerge from this environment is often paced more by the science enabled than by the innovation itself. One example of this has been the development of buoyancy-propelled UUV (Unmanned Undersea Vehicles) or underwater gliders [3].

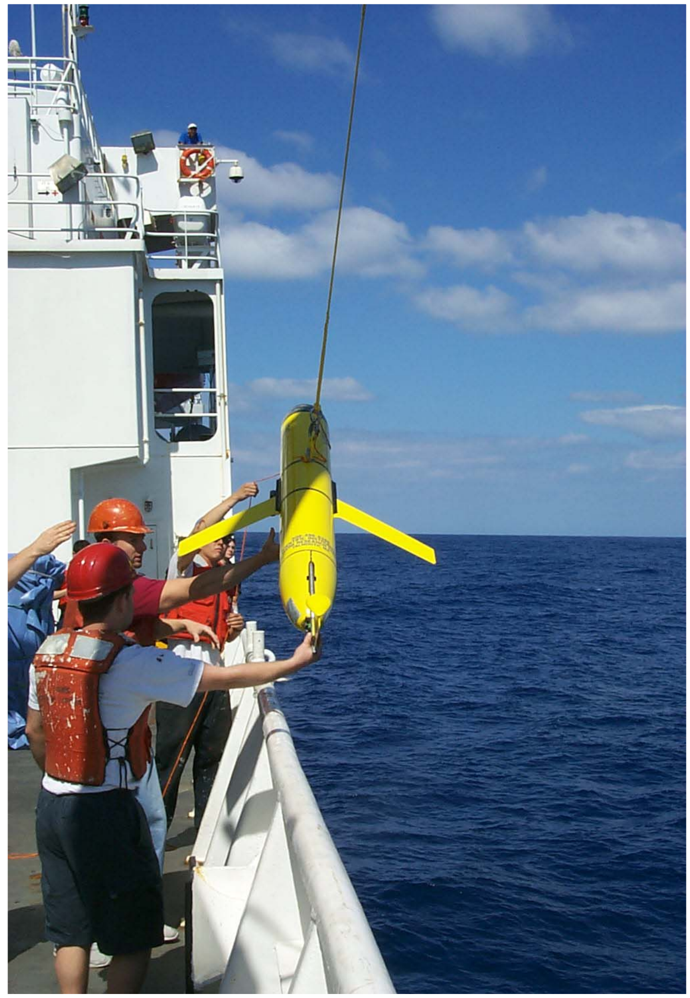

Figure 2. Launching an Underwater Glider
(Photo courtesy O. Schofield)

The use of gliders as a platform for a broad array of sensors has expanded rapidly and the reliability of this platform has dramatically increased since the first test deployments a few years ago. It may appear that the advent of this, now essential, addition to the oceanographer’s tool kit was an overnight occurrence. In reality, the development of these platforms has been in a slow evolutionary spiral for twenty years. Today’s underwater gliders represent a steady progression of incremental advances and additions to earlier buoyancy-driven sensor platforms capable of only vertical profiling [4].

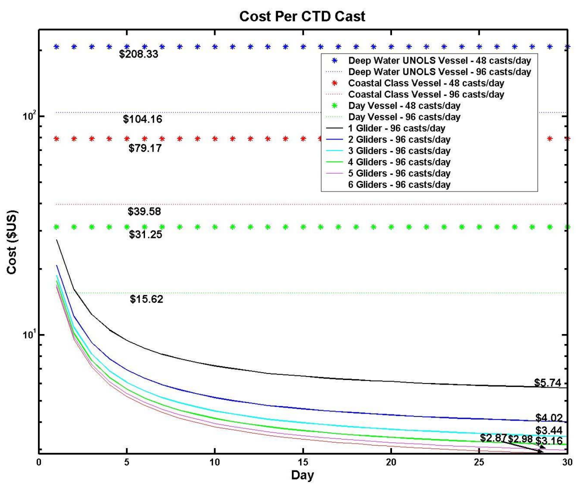

Figure 3. Economics of Underwater Gliders
(Courtesy O. Schofield)

The steady, yet relatively modest, stream of agency funding that enabled this continued evolution came largely as the result of the high-quality science enabled by these platforms [5,6]. It is the good fortune of the rest of the oceanographic community that those researchers submitting the proposals to collect these data are also themselves innovators of technology.

It is not only the international marine science community that has embraced gliders as sensor platforms. The United States Navy has also come to recognize these systems as an important asset and a cost effective force multiplier for operational oceanography. Figure 3 represents one projection of how a fleet of six unmanned gliders could be used to collect data at a potential two-order of magnitude cost savings over employing a large research vessel to obtain the same information.

The example cited above begs the question: had the significance of gliders and their potential for cost avoidance been recognized early on, could their development been accelerated? Is there a means or method outside the time-consuming, peer review-driven academic process that could be adopted to propel similar innovations to escape velocity from the Valley of Death?

The following Sections explore some other models extant within the private sector (large and small business) that might represent some alternatives worthy of consideration.

III. INDUSTRY SECTOR MODELS

A. *Large Business*

It is reasonable to look to the business arena for models to successfully complete the transition from idea to reality. Arguably, a high-tech innovation company must, by definition, be adept at accomplishing this, and be capable of doing so routinely in order to remain competitive. In the marketplace, invention and innovation is protected, frequently by patent or trade secret, but commonly, being first to market protects a competitive edge. First to market in this environment is typically measured in months, not years.

In 2005, the U.S. economy was estimated to be in excess of twelve trillion dollars [7]. Of this, perhaps only 2% (less than $250B) was reinvested into research. Much of that research is devoted to incremental improvements to existing products verses any sort of revolutionary new developments. A much smaller fraction, perhaps only a tenth of this fraction is invested by industry in high-risk, potential high-payoff research ventures [8]. Yet, these are the pursuits that can lead to truly innovative outcomes – emergent technologies that ultimately result in the process of "Creative Destruction" wherein existing methodologies and mature markets are supplanted by new ones [9, 10]. An example of this would be the advent of music Compact Discs (CDs) replacing the vinyl Long Playing (LP) record.

Typical phases of transitioning a concept from idea to the marketplace include, idea development, proof of concept, pilot, prototype, demonstration, and commercial sales (Fig. 4). Major corporations may have sufficient financial largess to internally fund all these phases, productizing a concept prior even to determining whether or not a sufficient demand exists to sustain it or even to recapitalize development costs through sales.

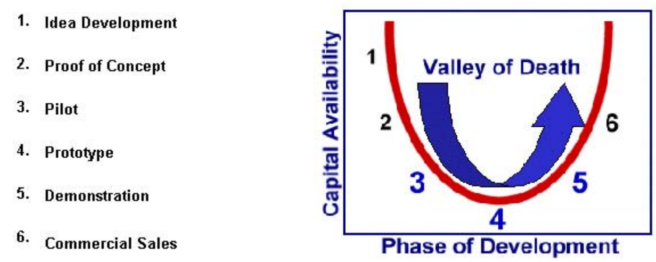

Figure 4. Large Business Transition Progression

Companies will not remain successful very long if they repeatedly invest in developments for which there is no market, and these investments are seldom undertaken without considerable prior deliberation, market survey and a convincing business plan. Nonetheless, it is those innovative firms who periodically "take a swing for the fence" who then benefit from maintaining their competitive edge in the marketplace over the more conservative or timid.

B. *Small Business*

The financial reality of most small businesses does not enable them to follow through all six phases depicted in Figure 4. Yet it is frequently within these small companies that the ocean technology community has benefited from new platforms and sensors that have successfully made the journey across the Valley of Death. If the academic community can be thought of as the wellspring of innovative thought and ideas, it has historically been the small businesses that service the oceanographic community who have "carrying the water" to the other side.

This journey is not without hardship and, as with the case in the Academic Sector, frequently ends in failure. Failure may be that the promising idea is never successfully transitioned to market, or may take the form of the company itself failing in the process of attempting that transition.

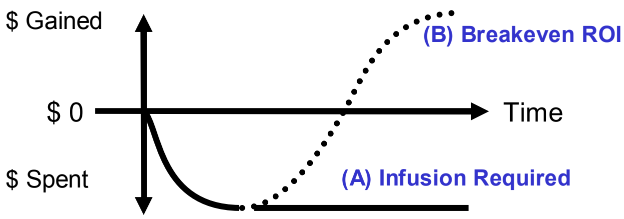

Figure 5. Small Business Technology Transition

When a small business attempts to make this transition with (typically) insufficient funding at some point (A) finances are exhausted and another stream of revenue must be located in order to continue the project to profitability (B) or to simply keep the company afloat (Fig. 5). In those instances where additional funds are in fact located, they typically come from one of a number of different sources. The first is prematurely rushing a prototype or even "brass board" to the market. One obvious downside to this is that a good idea that does not benefit from rigorous productizing can often deliver dismal performance, resulting in high visibility failure and ultimately a long-lasting legacy of rejection from the community at large. Another source of funds could be from infusion of venture capital; a so called "angel investor". Venture capital has played an increasingly significant role in this nation's high-tech development, but does not come without a potential price to the small business that accepts it. It is after all, an investment, and the Return On Investment (ROI) to the angel investor may take the form of ownership, in whole or in part, of the product or the company itself. The latter frequently involves sale of the company. Finally, some small firms approach (or are approached by) a larger company resulting in an acquisition of the small business. At one extreme, this paradoxically results in one less small business to worry itself about future excursions across The Valley. However, some large companies have recognized the value of owning smaller autonomous firms (wholly owned subsidiaries) allowing them to continue to operate and compete as a small business while serving as a sort of paternal banker, of both financial and technical resources.

IV. PARTNERSHIPS

At this late date, pointing out that partnering among academia, industry and government is vital to the success of these major ocean observing initiatives sounds as trite and hackneyed as this whole "Valley of Death" cliché itself. But perhaps nowhere is the need and potential benefit more self evident than in the current discussion. Already discussed was the fact that given enough time (and this might be measured on a decadal scale) the transition from science to societal impact may be successfully achieved in the academic environment. In large companies with large coffers, this transition is accelerated manifold, but at some considerable cost. In the ocean technology community, primarily due to the limited market size and demand, it has typically been the small businesses that have attempted (some successfully) the transition. This has occurred with external help, either from private sector concerns with better financing or from the federal government through one of a number of programs.

Two of the better known of these programs are the Small Business Innovative Research (SBIR) program and the Small Business Technology Transfer (STTR) program. Both programs are aimed at fostering commercialization of technical innovations in small business, the latter requiring a public/private partnership between a for-profit company and a nonprofit research institution or university. Table I lists those federal agencies that participate in these programs.

TABLE I
AGENCIES PARTICIPATING IN SBIR AND/OR STTR PROGRAMS

	AGENCY	SBIR	STTR
1	Dept of Agriculture	X	
2	Dept of Commerce	X	
3	Dept of Defense	X	X
4	Dept of Education	X	
5	Dept of Energy	X	X
6	Dept of Health Human Svc	X	X
7	Dept of Homeland Sec	X	
8	Dept of Transportation	X	
9	EPA	X	
10	NASA	X	X
11	NSF	X	X

Many of the small businesses that develop and provide sensors and platforms for use in the ocean observation initiatives have taken advantage of these Small Business Administration (SBA) programs. Both are three phase programs in which Phase I is a 6-month to one-year startup that funds exploration of the scientific, technical, and commercial feasibility of an idea. Phase II awards are for as long as two years, to expand Phase I results and begin to consider commercial potential. Phase III covers the period during which the innovation would actually move from the laboratory into the marketplace. However, no SBIR or STTR funds support this phase. The small business must find funding in the private sector or other non-STTR federal agency funding [11]. With the resources available to them, achieving commercialization within the time allotted for Phase I and II has proven elusive to small ocean technology firms.

The Federal government has also attempted to foster the transition among some of the nation's large businesses. As the result of the Omnibus Trade and Competitiveness (OTC) Act of 1988, The Department of Commerce's National Institute of Standards and Technology (NIST) established the Advanced Technology Program (ATP). ATP was created to provide cost-shared, competitive grants to industry to support R&D on high-risk, cutting edge technologies with broad commercial and societal potential [12]. Since its inception ATP has been

controversial. Deriding it as "corporate welfare," critics took exception to the government choosing which companies and technologies to support [13]. Their sentiment is that big business is both sufficiently adept and financed to successfully and routinely traverse “The Valley” and it is the market, not the government, that should decide which innovations should get the nod to proceed Now nearly twenty years after the OTC Act, and amid a growing concern regarding the state of innovation in the U.S., the current administration has proposed the American Competitiveness Initiative (ACI) that would double funding for three key physical sciences agencies over the next decade [10]. While the ACI will result in an immediate significant (twenty percent) increase in NIST’s Scientific and Technical Research Services (STRS) R&D funding, Congress has nonetheless endorsed the Administration’s proposal to eliminate the ATP. So, for the time being at least, it appears that partnerships between the Federal government and large businesses are not presently in vogue.

Though the tenure-driven, peer reviewed, competitive nature of the academic community tends to drive researchers toward independent verses collaborative work, the multidisciplinary nature of oceanography has always driven the best scientists to partnerships. History has proven that the most significant discoveries in ocean science have as the result of partnerships. As the community’s focus shifts from expeditionary to observational oceanography, there will be a concomitant shift towards more technology-intensive undertakings that require resources and talents found only in some of the country’s largest commercial firms. Architecting complex data and communication networks, designing and laying submarine cable and manufacturing reliable, robust high precision sensors for long-term deployment, or manning 24/7 Network Operation Centers are not among the core competencies of the academic community.

One notable partnership developed out of necessity by the ocean science community is found in the University National Oceanographic Laboratory System (UNOLS). This partnership between government and academia ensures competitive availability of some of the world’s best equipped and crewed research vessels to researchers from institutions of even the most modest means [14]. It is clear however that businesses, both big and small, will be key to the success of the partnerships that emerge to design, deploy, operate and sustain these major national assets. One variation proposed would involve private sector consortia operating observatories with bandwidth subscription (analogous to UNOLS ship time) competitively awarded by Federal agencies to researchers. Performance metrics and such industry benchmarks and best practices as Service Level Agreements (SLAs) would be in place to ensure Quality of Service and establish operation fees [15]. As with the evolution of UNOLS, necessity will dictate the emergence of these partnerships. Even adopting the most optimistic view as to the scale these observing systems will attain over the next 20 or so years, it is unlikely they will create a market of sufficient size to warrant the nation’s largest corporations to tool-up production lines to respond.

ACKNOWLEDGMENT

The authors wish to thank the conference conveners for allowing this un-timely submission on a very timely subject.

REFERENCES

[1] A. Isern, “Are Observing Systems Breaking down the Boundaries Between Research and Operational Oceanography by Moving Us Faster Through the “Valley of Death?, *Sea Technology Magazine*, July 2006.

[2] S. Ambrose, S. Habib, and R. McKellip, *“*Extending NASA Research Capabilities For Disaster Management”*, Earth Observation Magazine*, August 2005.

[3] R. Davis et. al., *“*Autonomous Buoyancy Driven Underwater Gliders”*,* G. Griffiths ed., Taylor and Francis, London, 2002.

[4] http://www.po.gso.uri.edu/rafos/

[5] O. Schofield, et. al., “Coastal Ocean Observatory for Studying Nearshore Coastal Processes”, *Backscatter*, 12: 34-37, 2001.

[6] Glenn, S., Coastal Predictive Skill Experiments at the LEO-15 National Littoral Laboratory. *Sea Technology*, 39(4): 63-69.

[7] *The World Fact Book*, U.S. Central Intelligence Agency (CIA), http://www.cia.gov/cia/publications/factbook/rankorder/2001rank.html

[8] L. Branscomb and P. Aurerswald, “ Between Invention and Innovation - An Analysis of Funding for Early-Stage Technology Development”, *NIST GCR 02–841*, 2002.

[9] J. Schumpeter, *Capitalism, Socialism and Democracy*, pp.82-85, Harper Press ed., 1942.

[10] American Competitiveness Initiative, White House Domestic Policy Council, Office of Science and Technology, 2006, http://www.whitehouse.gov/stateoftheunion/2006/aci/aci06-booklet.pdf.

[11] http://www.sba.gov/sbir/

[12] http://www.nist.atp.gov

[13] *American Institute or Physics Bulletin of Science Policy News*, No. 80.

[14] http://www.unols.org/info/unols.html

[15] A. Clark, “Industry’s Role in the Implementation of an Integrated Ocean Observing Capability”, *Proc of the MTS/IEEE Oceans ’02 Conference.*